Industrial Utilization of Surplus and Inferior Grades of Grain

The Problem

From a long-range viewpoint the Department's postwar programs for grain crops must provide means for securing a balance between production and market outlets if prices are to be stabilized at levels fair and equitable to both producers and consumers.

The yield of food and feed grain crops varies considerably from year to year due to uncontrolable factors such as weather, disease, and insects. Yet, people need to go right on eating and feeding in about the usual amounts. The upshot of this is that the only safe production goal for this Nation and its farmers is on the upper side of plenty. The outcome inevitably under such a goal of abundance is that in years of high yield, farmers will produce a great deal more than plenty, yet such a situation is infinitely to be preferred to a famine.

When the present world food crisis ends, farmers of America will face a difficult job of readjusting their production to fit peacetime needs. This will be particularly true for those food and feed grains which were expanded greatly as farmers responded patriotically to meet the wartime, domestic food, feed and industrial demands, and to supply food for starving peoples of a war-torn world.

We cannot expect the coincidence of war's destruction and poor crops in other countries of the world to continue to provide us with unusual markets. Except for these most unusual conditions, the Government might now or soon be confronted with the obligation of expending large sums of money to redeem its price support promises to farmers. The alternative would be for farmers to pay the penalty--in ruinously low prices--for their skill and industry in producing abundantly.

When the reconversion period will have ended and the peoples of war-town countries are again producing for themselves, our farmers will once more be faced with the problems of inadequate markets and low prices unless technological research results in the expansion of old and the creation of new industrial outlets for our grains.

The record of production and utilization of our corn crop illustrates the importance of the problem that we will be called upon to deal with. With an average production of 2,557 million bushels of corn and 822 million bushels of wheat per year during the four prewar years 1937-40 inclusive, the supplies of these two grains were sufficient to meet all requirements and at the same time provide carryover stocks of over 2 billion bushels for the Fall of 1941.

Corn and Wheat Stocks: October 3, 1941

Grain Owned by Commodity Credit Corporation	Bushels	Totals
Corn	153,000,000	
Wheat	176,000,000	329,000,000
Under Loan		
Corn	250,000,000	
Wheat	260,000,000	510,000,000
Free Grain Estimated (Corn and Wheat)		
Corn in Warehouses	100,000,000	
Corn on Farms	1,000,000,000	
Wheat in Warehouses	100,000,000	
Wheat on Farms	200,000,000	1,400,000,000
Total Stored Grains		2,239,000,000

Average production of corn for the 5-year period 1942-46 inclusive, was 3,147 million bushels while that of wheat for 1941-45 was 991 million bushels. Without a program of acreage adjustments, production in the years ahead may be expected to continue well in excess of 3 billion bushels of corn and 1 billion bushels of wheat annually, which would greatly exceed prospective market demand.

Such surpluses of grains, if permitted to pile up, might result in ruinous farm prices and a progressive unbalance between supplies and demand. In addition, the Government would have to carry out loan programs of such proportions as would lead to the accumulation of burdensome surpluses that would constitute a price depressant for future crops.

Thus, there is an urgent need for broadening and intensifying the field of industrial utilization of surplus and inferior grades of grain crops if we are to develop a well-rounded program to stabilize supplies and prices of food and feed grains.

RESEARCH ON THE PROCESSING AND UTILIZATION OF GRAINS

(Including Corn, Wheat, Oats, Grain Sorghum,
Barley, Rye, Buckwheat, and Rice)

From the standpoint of the principal chemical constituents, all cereal grains show a fairly close similarity. However, in minor chemical constituents and in physical characteristics wide differences exist. The physical characteristics of the grain determine largely the processing procedure that must be applied for efficient and proper separation of the kernel into its component or constituent parts.

Of the present processing procedures in use there are four general types, namely, dry-process milling, wet-process milling, fermentating, and saccharifying. The purpose of each type of processing is the separation of the grain into fractions or products uniform in either physical or chemical characteristics. For the most part the strictly industrial use of grain, as contrasted with food and feed uses, is concerned with the production and utilization of the starch, protein, and oil constituents in purified form or the transformation of some particular constituent of the grain such as in malting.

Current research on processing and utilization of cereal grains is limited principally to corn, wheat and grain sorghums. These investigations may relate to improving yields and quality of products, with process and product developments or with Fundamental research on cereal grains.

The success of departmental research in developing new processes and products has already shown the value of applied research on grains. In the last few years developments such as new processes for making wheat starch and sorghum starch and their conversion into sirups and sugar; the production of butylene glycol, vitamins, and penicillin; and improvements in existing dry-process and wet-process milling have resulted in the increased use of grain

Fundamental studies are being conducted on starch structure and starch properties, the composition of commercially marketed corn and wheat by grades and chief marketing centers, the oil content of inbred corn lines to assist in the development of a commercially suitable hybrid of high oil content, the detailed composition of the constituent parts of the corn kernel, and antibiotics from the bacterial species Bacillus polymyxa.

Pilot-plant research includes conversion of starch to saccharic acid, the wet-milling of corn, wheat, and grain sorghums, the conversion of corncobs to synthetic liquid fuels, degermination of corn by dry-milling techniques, and studies on the production of fungal amylases from fermentation byproducts.

Fields of Research Requiring Intensification and Expansion

Future research on the industrial utilization of grains for use in the production of motor fuels should be greatly intensified and expanded and new lines of investigations undertaken. The dwindling supply of petroleum in the United States, coupled with unsettled political conditions existing in other parts of the world where oil deposits occur, makes this course imperative.

In an adequate program for the utilization of cereal grains for the production of motor fuels, research should be initiated on the following subjects: The use of substandard or damaged commodities as raw materials; improvement of distillation and byproduct recovery; modifications of producing and recovering the byproduct feed; improving the quality of byproduct feed; investigating on a pilot-plant scale processing methods and costs of conversion for all of the cereal grains and evaluating the resultant byproduct feed in cooperation with Experiment Stations; investigating the quality of fuels and their proper methods of use in full-scale engines and in road-tests. Reduction of conversion costs by the use of mold amylases as replacements for malt holds great promise, and the line of attack should be intensified.

Background knowledge on the physical, chemical, and structural interrelationships of the oil, protein, and starch as they occur in the grain kernel is important to all types of processing. The current small research program on this subject should be greatly expanded so that the information is immediately available to all engaged in processing and production studies.

The various laboratory developments such as industrial alcohol from granular wheat flour; starch, sirups, and gluten from wheat flour; the wet-milling of wheat grain; etc., have provided new large outlets for wheat. Work on wheat in other Bureaus, State Experiment Stations, and outside organizations is often confined to food uses and specific types of wheat. The many efforts are scattered and uncoordinated. There is need for a unified program on wheat to include all phases of milling technology, food uses, industrial uses, and the development of new products.

The industrially important constituents of grains are starch, protein, and oils. At the present time starch is consumed largely as such or in the forms of glucose sirup and dextrose sugar. Possible new products which should be developed are modified starches for a variety of industrial uses; chemical intermediates for plastics, films, and fibers; and chemicals and chemical intermediates from dextrose, which is in turn produced from starch. The starch contained in cereal grains can be converted by fermentation into chemicals and solvents, including alcohol, citric acid, and lactic acid. Additional work is needed in order to develop methods for the production of a variety of industrial solvents, chemicals, and raw materials by fermentation of glucose and starch.

Methods should be improved for recovering proteins from cereal grains and for chemically modifying them for conversion into fibers, films adhesives,

protective coatings, and plastics. Some of the major research problems pertaining to wheat gluten have as objectives:- (1) To develop economical methods for drying gluten without denaturation. Native (undenatured) gluten has properties of greater utility for industrial usage than has denatured gluten. For example, when mixed with plasticizers, it can be milled and pressed into rubber-like sheets. (2) To develop water-resistant plasticizer for gluten. The demonstration that large amounts of fats can be incorporated into gluten increases the possibility that this may be a feasible project. (3) To develop methods for separating gliadin from gluten. Gliadin has properties similar to zein, and, if separation can be accomplished, may be equally adaptable for use as a material for fibers, sizings, etc. (4) To develop new chemical derivatives of wheat gluten and of its separated components. The possibility of uniquely modifying the properties of gluten for new uses requires further study. (5) To investigate the specific usefulness of the nitrogenous constituents of whole wheat, gluten, and residues from the manufacture of glutamic acid, as supplements in connection with the microbiological production of biological compounds including antibiotics and enzymes; and food or feed supplements or flavoring agents. (6) To investigate further the starch splitting enzymes of wheat, with particular reference to the baking properties of flour.

Methods should be developed for improving the efficiency with which oil is recovered in the processing of cereal grains--particularly in the case of corn. Vegetable oils are excellent as foods, but methods should be developed for converting them into drying oils, ester gums, and industrial coatings.

The field of antibiotics, which was given such impetus by the discovery of penicillin and streptomycin, should be investigated further with a view to developing new materials of this type. The mold, bacteria, and yeast collection available of the Department is one of the largest in the world, and should be surveyed and screened with the aim of developing new antibiotics, particularly those which would be effective in the treatment of milk fever and tuberculosis.

INTEGRATION AND IMPLEMENTATION OF RESEARCH PROGRAMS

It is well known that the prewar operation of the Ever Normal Granary resulted in an ever increasing granary. It was only by the costly grace of war that the 1941 carryover of about 2.4 billion bushels of weevil infested corn and wheat (some dating back to 1936) was used up. Surpluses need to be syphoned off into industry and not stored. Correlation of data pertaining to government-owned corn, and prices received by farmers during the period 1939-1941 indicates that the physical presence of large supplies of government-owned grain has a depressing influence on the prices received by farmers. It appears essential, therefore, to move surplus and low-quality grains into industrial channels.

There are four major non-food channels into which grains can be moved. Technologic as well as other factors are involved in the success of such movements. It appears, however, that by appropriate implementation the problem of grain surpluses can be solved.

1. Industrial Alcohol and Motor Fuel

The use of grains for the production of industrial alcohol could advantageously supplement our limited and dwindling petroleum reserves. Indeed, by using a motor fuel blend containing less than 5 percent of alcohol from grains, the problem of surpluses in these commodities could be completely solved. It would appear appropriate that the heavy grain producing areas take the lead in exploring the solution of this problem.

2. Expanded Dextrose Production

During the past decade the industrial markets for dextrose (and glucose sirups) have increased markedly, largely because of wartime factors. It is a certainty, however, that the ice cream, confectionery and bakery trade will in all likelihood continue to use these sweeteners at compara-

tively high levels. Such industries, because of the magnitude of their operations can blend a related number of barrels of dextrose and sugar which contributes to the production of a product having satisfactory to advantageous properties. Household consumers, however, cannot conveniently do this. In fact, it is quite difficult to make retail purchases of dextrose, notwithstanding the fact that its virtues are widely advertised.

If arrangements could be made to promote the packaging of mixtures of sucrose and dextrose in customary and convenient sizes for use in households, the household consumer would have the same opportunity as industry for using a blend of the two sugars.

If a widespread household acceptance of an 80-20 sucrose-dextrose ("Surose") mixture could be developed it would afford a potential market for 630,000 tons of dextrose-requiring roughly 40 to 50 million bushels of corn. The fruition of such a development would lessen our dependence on foreign sources of sugar and would put us in a better bargaining position in negotiating international sugar agreements.

3. Strategic Material Stockpiles

Pursuant to the Stockpiling Act of 1946, the Army-Navy Munitions board has included ethyl alcohol, butyl alcohol and glycerol in a preliminary list of critical chemicals. All of these materials can be derived from grains by fermentation processes. The technology of their production is being studied by the Department. The Government owns wartime facilities in the heart of the heavy grain producing area which can be employed for processing off grade and surplus grain into products needed for national defense.

It would appear to be in the interest of agriculture, the national defense and the public welfare to integrate the utilization of surplus grains, and the production of strategic materials in accordance with the provisions of the Stockpiling Act.

4. New Products, New Uses and Technological Research

In previous paragraphs mention has been made of some of the new products which have been derived from the constituents (starch, proteins, oils) of grains. Progress in this field can promptly be translated into industrial production for there is no dependence on legislation or new patterns of use. Research will surely develop increased industrial markets for grains. The tempo of progress, however, may be too slow to take care of the surplus grains which may reasonably be expected before many harvests.

If technology can be harnessed to one or more of the indicated fields of consumption it is altogether likely that the problem of grain surpluses can be brought under control.